# DRAFT WORK PLAN

FOR

# HYDROGEOLOGIC AND GEOTECHNICAL STUDIES

FOR THE

# MAYFLOWER TAILING SITE

# WASATCH COUNTY, UTAH

PREPARED BY:

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MARCH 1987

DRAFT

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## EXECUTIVE SUMMARY

This document is a work plan for conducting field, laboratory and office studies for the Mayflower tailing site in Wasatch County, Utah. The majority of the proposed work plan will consist of hydrogeologic and geotechnical investigations which will include soil, tailing and groundwater sampling and analysis and geochemical studies. This plan defines the scope, budget and schedule for the proposed activities. The main objectives of the study are to (1) assess whether significant environmental contamination has occurred at the Mayflower tailing site, (2) evaluate the proposed site development in light of the environmental study results, and (3) evaluate the feasibility of relocating the Olsen-Neihart tailing to the Mayflower tailing site.

The Mayflower tailing site is located between Park City and Heber City in Wasatch County, Utah as shown on Figure 1. The tailing deposits are located in three unlined impoundments which are shown on Figure 2. It is estimated that there are approximately 400,000 tons of tailing which were deposited between 1962 and 1972 to an average depth of 16 feet.

The Olsen-Neihart tailing site is located approximately one mile southeast of the Mayflower site as shown on Figure 1. It is our understanding that tailing were deposited in this impoundment during the 1960's and 1970's, resulting in a total volume of approximately 200,000 tons. The tailing should be similar to those deposited at the Mayflower site since they came from the same general source, the Mayflower Mine. The USBR plans to relocate the Olsen-Neihart tailing because the Jordanelle Reservoir will inundate the tailing site, potentially releasing heavy metals into the reservoir.

The work plan, which has been developed for the Mayflower site, is proposed to be executed by Bingham Engineering and Delft Soil Mechanics Laboratory (Delft). In addition, the U.S. Department of Interior, Bureau of Reclamation (USBR) will obtain additional information at the Olsen-Neihart site. Technical review will be performed by the State of Utah-Department of Health (UDH),the Wasatch County Department of Health (WDH) and the USBR. The USBR is involved primarily due to the Jordanelle Dam project which necessitates the relocation of the Olsen-Neihart tailing. The UDH is overseeing the studies to determine if the proposed plans will meet environmental regulations, and Wasatch County will be involved in a review of the plans to determine if the plan is in compliance with the conditions attached to the property determinations for the Mayflower Development. Bingham Engineering is performing the planning and engineering for the Mayflower Recreational Development. Delft has been retained by the owners of the Mayflower development to evaluate the potential environmental contamination.

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## 1.0 INTRODUCTION

This document presents a work plan and quality assurance guidelines for field exploration, laboratory analysis and office activities which will be performed for the Mayflower tailing site. This study will include hydrogeologic and geotechnical investigations, groundwater sampling and geochemical evaluations. The work plan was developed by Bingham Engineering and Delft Soil Mechanics Laboratory and it will be reviewed and approved by the UDH, WDH, the USBR and Mayflower Stichtings prior to implementation.

The hydrogeologic investigation will consist of 16 drill holes/piezometers which will be drilled and installed to identify and characterize the subsurface soil, bedrock and groundwater conditions. The geotechnical investigation, in addition to the information developed as part of the hydrogeologic phase, will consist of 12 drill holes to characterize the Mayflower tailing and containment dikes. In addition, several test pit excavations and shallow sampling holes will be included in the field program.

The first round of groundwater sampling will be performed in the 16 piezometers/monitor wells to determine areas of potential contamination and also obtain baseline data. Geochemical testing will be performed on samples of tailing and soil to characterize the materials.

# 2.0 PROJECT DESCRIPTION: OBJECTIVES AND SCOPE OF WORK

## 2.1 GENERAL OBJECTIVES

The primary objectives of this study are to 1) identify and characterize any contamination in the soil and/or groundwater in or adjacent to the Mayflower tailing site, (2) characterize the Mayflower and Olsen-Neihart tailing, (3) evaluate the proposed site development in light of the environmental study results, (4) evaluate the feasibility of relocating the Olsen-Neihart tailing to the Mayflower tailing site.

## 2.2 SITE DESCRIPTION

### 2.2.1 Mayflower Tailing

The existing Mayflower tailing are contained within three unlined impoundments covering approximately 5 acres as shown on Figure 2. The site contains approximately 400,000 tons of tailing processed by flotation of ore from the Mayflower mine between 1962 and 1972. The tailing were deposited at approximately 30% solids by volume, with the existing deposits having densified to between 40 and 50 % solids. It is our understanding that the containment dikes were constructed of native soils which consisted of relatively low permeability gravelly clays and clayey gravels. There is some conflicting information related to the method of discharge, however, apparently Pond 1 was filled by discharging from one or two upstream points. Hecla, the company operating the mine, began experiencing slope instability problems with the dike around Pond 1. It appears that they later modified their discharge to utilize a perimeter discharge system, thus a beach of coarser sand material was deposited along the flank of the dam. However, it is believed that the majority of the tailing were deposited in the three ponds from a single point upstream of each of the ponds. This conclusion conflicts with a recent report (Barnes-Phariss Associates, 1983) which states that the dikes had internal drains and that perimeter discharge was used for a majority of the tailing deposition.

### 2.2.2 Olsen-Neihart Tailing

The existing Olsen-Neihart tailing pond is located about 1 mile below the Mayflower tailing site. This impoundment, which is located in the original McHenry Creek Channel, was used to deposit tailing from the Mayflower Mine during the 1960's to 1970's. The tailing were the by-product of a flotation process similar to that used for the tailing at the Mayflower site. It is estimated that 200,000 tons of material were placed in this tailing impoundment.

The USBR is in the process of constructing the Jordanelle Dam to be located on the Provo River downstream of the Olsen-Neihart tailing site. The Jordanelle Reservoir will inundate the tailing and there is concern that heavy metals could leach into the reservoir The reservoir will be a source of drinking water. Therefore the USBR has decided to relocate the tailing to a site outside of the reservoir. One site being considered is the existing Mayflower tailing site.

## 2.3 EXISTING INFORMATION

### 2.3.1 Mayflower Tailing Site

The USBR has performed some exploration borings and test pits within the general site area. Two of these borings are shown on Figure 2. These borings provide general geologic information such as depth to bedrock and groundwater depths.

Four exploratory borings were drilled within the upper impoundments (Tailing Ponds 1 and 3) by Bingham Engineering in March of 1983. The purpose of this investigation was to determine the total depth of the tailing and evaluate the stratification of the deposits. The engineering characteristics were also determined for selected samples to provide input in evaluating alternative methods of stabilizing the tailing. Two reports were generated from this study, one dealing with the engineering properties and the other dealing with the long-term reclamation of the site.

### 2.3.2 Olsen-Neihart Tailing Site

Two studies have been conducted at the Olsen-Neihart site to evaluate the hydrogeologic conditions. One of these studies was completed by the USBR in 1982 and consisted of chemical and petrographic analysis of 15 samples collected from the site. A separate study is presently being conducted under the direction of the UDH. This program is currently underway and final data was not available at the time this work plan was prepared.

## 2.4 GENERAL SCOPE OF WORK

The scope of work required to perform the study includes:

1. Review, compile and summarize available hydrologic, geologic, geochemical and geotechnical data for the Mayflower and Olsen-Neihart tailing sites.

2. Perform hydrogeologic investigations at the Mayflower site to define subsurface soil, rock and groundwater conditions and identify any on-site contamination. This task includes drilling, logging and sampling at the new monitor well sites, installation of wells and groundwater sampling.

3. Perform geotechnical investigations to define the subsurface conditions at the Mayflower site. This will include drilling, logging and sampling of tailing, dikes and natural soil deposits, and then the performance of laboratory tests to determine engineering properties. In addition, test pits will be excavated within potential borrow areas.

4. Perform laboratory analyses including geotechnical, geochemical and water quality tests.

5. Complete office evaluations including geochemical evaluations, assess the potential for environmental contamination and engineering evaluations related to development/reclamation of the site.

6. Prepare a summary report of the field, laboratory and office activities. The conclusions and recommendations will be included in this report.

In completing this study 27 drill holes are proposed to be placed in the tailing ponds and dikes and in the surrounding natural terrain. The majority of these holes will be completed as monitor wells and/or piezometers. Figure 2 presents the proposed locations of these drill holes and also indicates the locations of existing borings which were drilled by the USBR and Bingham Engineering.

## 3.0 PROJECT MANAGEMENT

### 3.1 Project Team

The majority of the tasks will be performed by personnel from Bingham Engineering and Delft. Bingham Engineering will be responsible for executing all field and laboratory activities and all geotechnical engineering related office studies. Delft will be responsible for the hydrogeological and geochemical studies.

The proposed organizational chart, which is shown on Figure 3, indicates the roles of key personnel. The project team will consist of two project managers who will have control over all aspects of the field and laboratory programs. Their responsibilities will also include coordination and transfer of all pertinent data to Delft for use in their interpretation. Bingham Engineering personnel are experienced in the drilling, logging and sampling of exploration holes, the completion of monitor wells, groundwater sampling and laboratory analysis. We propose to subcontract the drilling and backhoe work and the chemical analysis testing.

### 3.2 Quality Assurance Project Plan (QAPP)

A quality assurance plan has been developed and is included here as Appendix A. This plan will be carefully followed throughout the project to assure compliance with all pertinent requirements.

### 3.3 Health and Safety Plan (HASP)

An approved health and safety plan will be incorporated into the program which will include all pertinent requirements and monitoring to assure compliance with federal and state procedures.

# 4.0 HYDROGEOLOGIC/GEOCHEMICAL INVESTIGATIONS

## 4.1 General

Preliminary studies have indicated slightly elevated levels of some metals at the Mayflower site. The hydrogeologic and geochemical study will be directed toward determining the nature and extent of the potential contamination at the Mayflower site, to evaluate the potential pathways of migration of the contaminants and to assess the actual and potential risks, if any, those contaminants pose to public health and the environment. The primary concerns are whether and to what extent heavy metals are leaching out of the tailing impoundments and entering surface water, groundwater and/or native soils. Potential releases into the air will also be considered.

The hydrogeologic investigation will be conducted to provide sufficient technical data to assess the potential contamination and determine what site reclamation method(s) would minimize the threat of future contamination. The investigation will consist of drill holes/monitor wells placed within and through the tailing ponds and around the perimeter of the impoundments. The proposed drill holes will be located so as to obtain soil and water samples to develop subsurface soil, bedrock and groundwater information. We propose to extend two drill holes to bedrock, one upstream and one downstream of the tailing impoundments. Additional drill holes/monitor wells are proposed to extend into the upper aquifer zone up-gradient, down-gradient and on the sides of the impoundment area.

There is some uncertainty as to the groundwater depths in the vicinity of the tailing site. Water levels have been measured at or near the original ground surface below the ponds. However, USBR data indicates groundwater levels on the order of 100 to 200 feet below the ground surface. The measurements of water below the ponds may be perched and be the result of a groundwater mound which developed from water seeping out the bottom of the impoundments. Therefore, to further define the location of the upper aquifer, which could be the potential pathway(s) for contamination to migrate, we propose a phased approach to the hydrogeologic investigation. Initially a single drill hole, located down-gradient of the impoundments will be extended into the upper most aquifer. Based on this information the depths of the other drill holes will be adjusted (see Table 1) if necessary. This may result in a reduction in the proposed drill hole depths and work plan costs.

After completion of the drill holes, water quality samples will be obtained from the completed monitor wells. Laboratory tests will be performed on soil, tailing and water samples.

Details of the field and laboratory procedures are included in the QAPP in Appendix A.

## 4.2 Field Studies

The field program will include the following specific activities:

Drilling, sampling and logging
Construction of piezometers/monitor wells with proper development.

Install inclinometers (if necessary) and obtain base line readings
Perform slug tests
Conduct water sampling
Survey in boring locations and elevations
Obtain periodic water level measurements

Details of the proposed field procedures are included in Appendix A.

4.3 Laboratory Testing

The laboratory testing program will consist of the physical testing of soil and rock and the chemical analyses of tailing, soil and groundwater samples. The majority of the soils testing will be completed in our laboratory in Salt Lake and the chemical tests will be conducted by State of Utah certified chemical laboratories.

Chemical testing will include determining the chemical constituents of representative tailing, soil and groundwater samples. Testing will also include leachability tests of the tailing and geochemical tests on the subsurface soils to determine their ability to absorb metals leaching from the impoundment area.

Details of the proposed soil and water quality parameters and general laboratory procedures and quality assurance methods are provided in Appendix A.

4.4 Office Studies

****This section to be provided by Delft****

## 5.0 GEOTECHNICAL INVESTIGATION

### 5.1 General

The geotechnical investigation will be conducted at the same time as the hydrogeologic investigation. Where possible samples and other information will be obtained from the same borings as the hydrogeologic study. This procedure has been taken into account in developing the proposed work plant.

The intent of the geotechnical investigation will be to collect subsurface information for the tailing, dike material and native soils. Samples will be collected so engineering properties can subsequently be determined in the laboratory testing program.

### 5.2 Field Investigation

The proposed field exploration program is broken down into the specific activities outlined below. The actual location of borings will be subject to change depending on information collected at other drill hole locations.

Drilling, sampling and logging
Construction of piezometers
Excavation, sampling and logging of test-pits
Water level measurements
Site reconnaissance
Survey location and elevation of borings

The drilling and sampling will be directed toward obtained representative undisturbed and disturbed soil samples. These samples will be used to determine in-situ density and moisture, and determine strength, compressibility and permeability values. Piezometers will be installed to measure the existing phreatic surfaces within the tailing and native soils. In addition to the drill holes, we propose to obtain hand samples of the tailing deposits, and excavate test pits in potential borrow areas.

### 5.3 Laboratory Testing

All samples recovered during the field exploration program will be sent to the Bingham Engineering materials testing lab in Salt Lake City for further classification and testing as required. Once the field program is complete a testing program will be established to classify the materials collected and conduct consolidation, permeability and strength tests for use in the design studies. Samples or mixtures of samples representative of those to be used in the reclamation of the tailing will be selected for triaxial testing. The general soil testing planned is outlined below.

Moisture and Density
Triaxial testing
Direct shear testing
Consolidation testing
Plasticity index testing

Gradation analysis
Compaction testing
Permeability testing

## 5.4 Engineering Analysis

### 5.4.1 General

The engineering studies and analyses will be directed toward evaluating the existing and proposed tailing reclamation configurations. This will include evaluating the development methods as they relate to constructability, stability and settlement potential. A preliminary analysis of their potential affect on the proposed development plan for the Mayflower Recreation area will be conducted as well.

The basic reclamation alternatives under consideration include (1) draining the tailing, flattening the side slopes and possibly densifying the tailing to use the site as a parking area or other open space, or (2) placement of Olsen-Neihart tailing over the existing Mayflower tailing, (3) combining the three tailing ponds into one or two consolidated ponds.

### 5.4.2 Stability Analyses

The stability of the tailing impoundments must be addressed for the existing and any proposed reclamation alternatives. This includes evaluating the static and seismic stability (deformation and liquefaction potential) of the tailing and containment dikes. The static stability of the existing impoundments should be adequate based on the fact that the phreatic surface has been much higher in the impoundments than it is now and no dikes show evidence of failure.

The seismic stability of the existing dikes is of concern and liquefaction of the tailing and deformation of the containment dike could occur resulting in loss of some of the tailing material. However, since all reclamation alternatives should include the flattening of slopes, draining and densifying of the tailing which will reduce/minimize the potential failure during a seismic event, we have not, as part of this work plan, included a detailed seismic stability evaluation of the existing tailing impoundments.

We propose to evaluate the static and seismic stability of selected reclamation alternatives. Seismic evaluations will include pseudo-static and/or simplified dynamic analyses to assess the deformation and liquefaction potential. In addition these stability analyses will aid in selecting proper design slopes for the various alternatives.

Stability analyses will be based upon field and laboratory data developed as part of this plan.

### 5.4.3 Settlement

Results of the testing program will also be used to asses settlement of the tailing, foundation and embankment soils based on the different design alternatives. The settlement analyses will aid in selecting proper reclamation method(s) based on site

development requirements. It is anticipated that some form of tailing densification will be required as part of the reclamation activities.

### 5.4.4 Construction Methods and Alternatives

The engineering analyses will also include evaluating various construction methods to determine the most feasible, cost effective approaches. This will include evaluating whether to use on-site or imported fill materials as construction materials.

## 5.5 Conceptual Design

Conceptual designs will be developed for the preferred reclamation alternatives. The conceptual designs will be developed using the stability, settlement and constructability results. These designs will be used to develop estimates of reclamation costs and schedules.

## 5.6 Cost Estimates For Alternatives

As discussed, several design alternatives are being considered which will be acceptable to the control and retention of the tailing material and fit in with the overall Mayflower development master plan. Obviously there are minimum design requirements which must be met to comply with the State and Federal regulations. Each of the alternatives will be broken down into the purpose for the option and the cost. The costs will be developed using appropriate equipment and personnel rates based the latest publications. All aspects of construction will be taken into account such as access and availability of on-site borrow versus imported material.

## 5.7 Summary Report

A summary report will be prepared to provided all concerned parties with a summary of geotechnical data collected during this study and a listing of associated design requirements. The report will include the results of all field and laboratory investigations with logs and testing summaries. Results of all analytical efforts such as stability analysis and other technical information used in design will also be provided. A section of the report will be a description of the various options and the associated costs and benefits to the overall project.

# 6.0 PROJECT SCHEDULE

The project schedule is presented as Figure 4. This schedule is based on sequencing all of the phases so that some of the materials testing and other analysis can begin while the field program is still going on. The results of tests will be forwarded to the appropriate agencies and owners at least monthly.

The scheduling is subject to minor changes however, there are certain items which must follow a critical path and be completed very close to the schedule provided.

## 7.0 PROJECT COSTS

The project costs presented on Table 3 are based on the proposed locations and depths of borings/piezometers and the sequencing of events in compliance with the attached schedule. Some of the amounts are estimates based on experience on similar projects.

At the time of preparation of this draft there were no chemical analysis guidelines available form Delft. Consequently we have made rough estimates. It is our understanding that this information is being forwarded from Delft and will be incorporated into the final work plan prior to final approval.

## 8.0 REFERENCES


1 Letter from Dr. ir. M. Loxham, Delft Soil Mechanics Laboratory, to Clark Mower. Drilling Campaign Mayflower Tailings, dated February 2, 1987

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8 U S Dept. of Commerce, National Technical Information Service, 1977, Procedure Manual for Ground Water Monitoring At Solid Waste Disposal Facilities, U.S. Environmental Protection Agency, Washington D.C.

9 Hillman J. et al, February, 1984, Guidance for the Development of a QA Plan

10 Office of Monitoring Systems and Quality Assurance, Office of Research and Development, U S Environmental Protection Agency, October, 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80, Washington, D.C.

11 U S Environmental Protection Agency, Minimum Quality Assurance Requirements for a Monitoring Program,

TABLE 1

MAYFLOWER TAILINGS STUDY
HYDROGEOLOGIC INVESTIGATION
DRILL HOLE DETAILS

| HOLE NO. | MIN. BORING DIA (IN) | PIEZO DIA (IN) | EST. BORING DEPTH (FT) | SCREEN LENGTH (FT) | BORING LOCATION (TO TAILINGS) | EST WATER LEVEL (FT) | EST BEDROCK DEPTH (FT) |
|---|---|---|---|---|---|---|---|
| SD-1 | 8.0 | 4 | 120 | 10 | DOWNSTREAM | 100 | 240 |
| MD-1 | 8.0 | 4 | 180 | 10 | DOWNSTREAM | | |
| DD-1 | 8.0 | 4 | 250 | 10 | DOWNSTREAM | | |
| SD-2 | 8.0 | 4 | 195 | 10 | EAST | 175 | 260 |
| SD-3 | 8.0 | 4 | 170 | 10 | DOWNSTREAM EAST | 150 | 250 |
| SD-4 | 8.0 | 4 | 120 | 10 | DOWNSTREAM | 100 | 220 |
| SD-5 | 8.0 | 4 | 120 | 10 | DOWNSTREAM SOUTH | 100 | 180 |
| SD-6 | 8.0 | 4 | 220 | 10 | UPSTREAM | 200 | 260 |
| SD-7 | 8.0 | 4 | 145 | 10 | UPSTREAM | 125 | 230 |
| DD-7 | 8.0 | 4 | 240 | 10 | CENTER | | |
| TD-8 | 8.0 | 4 | 12 | 5 | POND 3 | 16 | 230 |
| SD-8 | 8.0 | 4 | 30 | 10 | POND 3 | 17 | |
| TD-9 | 8.0 | 4 | 15 | 5 | POND 1 | 17 | 230 |
| SD-9 | 8.0 | 4 | 33 | 10 | POND 1 | 20 | |
| TD-10 | 8.0 | 4 | 12 | 5 | POND 2 | 15 | 230 |
| SD-10 | 8.0 | 4 | 28 | 10 | POND 2 | 18 | |
| TOTAL FOOTAGE | | | 1890 | | | | |

TABLE 2

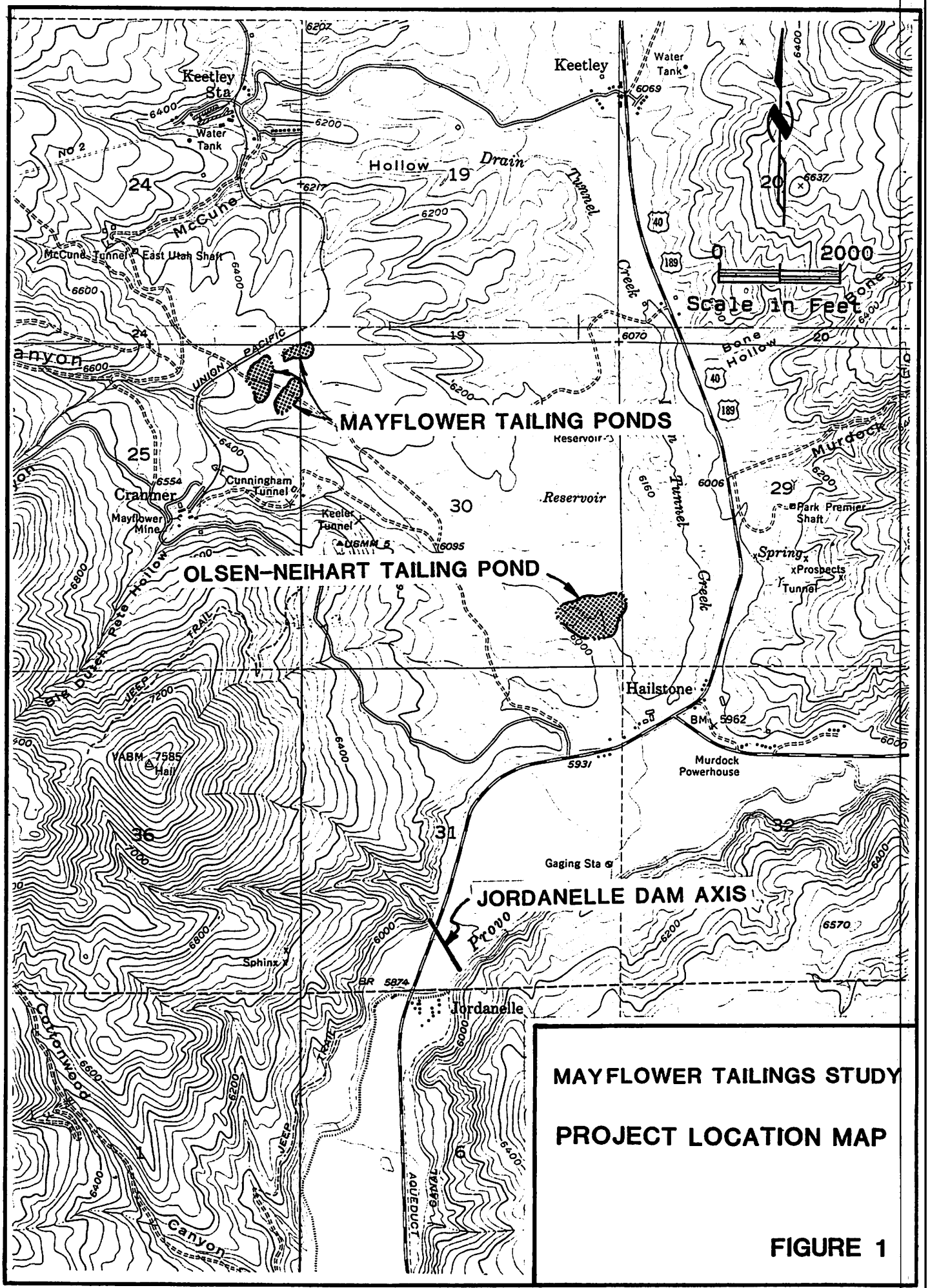
MAYFLOWER TAILINGS STUDY
GEOTECHNICAL INVESTIGATION
DRILL HOLE DETAILS

| HOLE NO. | MIN. BORING DIA (IN) | PIEZO DIA (IN) | EST. BORING DEPTH (FT) | BORING LOCATION (TO TAILINGS) | EST. WATER LEVEL (FT) | EST. BEDROCK DEPTH (FT) |
|---|---|---|---|---|---|---|
| DH-6 | 6-8 | 2 | 35 | POND 1, S EAST TAILINGS | 17 | 240 |
| DH-7 | 6-8 | 2 | 40 | POND 1, EAST EMBANKMENT | 17 | 240 |
| DH-8 | 6-8 | 2 | 40 | POND 1, SOUTH TAILINGS | 17 | 240 |
| DH-9 | 6-8 | 2 | 30 | POND 3,SOUTH TAILINGS | 15 | 250 |
| DH-10 | 6-8 | 2 | 40 | POND 3, SOUTH EMBANKMENT | 15 | 250 |
| DH-11 | 6-8 | 2 | 30 | POND 3, EAST TAILINGS | 15 | 250 |
| DH-12 | 6-8 | 2 | 30 | POND 3, EAST EMBANKMENT | 15 | 260 |
| DH-13 | 6-8 | 2 | 30 | POND 2, EAST TAILINGS | 15 | 250 |
| DH-14 | 6-8 | 2 | 60 | POND 2, EAST EMBANKMENT | 15 | 250 |
| DH-15 | 6-8 | 2 | 20 | POND 2, SOUTH TAILINGS | 15 | 250 |
| DH-16 | 6-8 | 2 | 60 | POND 2, SOUTH EMBANKMENT | 15 | 250 |
| DH-17 | 6-8 | 2 | 35 | POND 1, EAST TAILINGS | 17 | 240 |
| TOTAL FOOTAGE | | | 440 | | | |

TABLE 3

SUMMARY OF COST ESTIMATES

| | | |
|---|---|---|
| HYDROGEOLOGIC/GEOCHEMICAL PHASE (does not include Delft Input) | FIELD EXPLORATION | $137,705.50 |
| | LABORATORY TESTING | $27,554 |
| | EVALUATION AND ANALYSIS | $11,100 |
| | SUBTOTAL | $176,360 |
| GEOTECHNICAL PHASE | FIELD EXPLORATION | $29,440 |
| | LABORATORY TESTING | $13,990 |
| | ANALYSIS AND DESIGN | $10,600 |
| | REPRORT PREPARATION | $14,900 |
| | SUBTOTAL | $68,930 |
| | PROJECT MANAGEMENT | $26,000 |
| | TOTAL | $271,290 |
| | CONTINGENCY (10%) | $27,129 |
| | PROJECT TOTAL | $298,418 |




MAYFLOWER TAILINGS STUDY

PROJECT LOCATION MAP

FIGURE 1